Programme	BS Computational Statistics and Data Analytics	Course Code	CSTA-305	Credit Hours	3
Course Title	Bayesian Analysis				

Course Introduction

Bayesian Analysis and Application: Bayesian statistics offers a probabilistic framework for updating beliefs based on evidence. Students learn Bayesian inference, prior and posterior distributions, Markov Chain Monte Carlo (MCMC) methods, and Bayesian modeling for complex data analysis.

Learning Outcomes

By the end of this course, students will be able to:

1 To introduce students to the Bayesian approach and its fundamental principles.
2 To develop a comprehensive understanding of Bayesian probability and inference.
3 To equip students with the skills necessary for applying Bayesian techniques to practical problems.

Course Content		Assignments/Readings
Week 1	**Unit – I** Concept of Probability: Introduction to probability theory and its applications	
	Unit – II Basic probability concepts: sample space, events, probability axioms	
Week 2	**Unit – III** Conditional Independence: Understanding conditional probability and conditional independence	
	Unit – IV Applications of conditional independence in probability models and statistical inference	
Week 3	**Unit – V** Exchangeability, Bayes Theorem: Explanation of exchangeability in probability models	
	Unit – VI Introduction to Bayes' theorem and its significance in Bayesian inference	
Week 4	**Unit – VII** Different Types of Prior and Their Uses: Overview of different types of prior distributions: conjugate priors, non-informative priors, informative priors	
	Unit – VIII Understanding the role of priors in Bayesian inference and decision-making	

Week 5	**Unit – IX** Inference Based on One-Parameter Model (Binomial and Poisson): Statistical inference for binomial	
	Unit – X Poisson distributions using Bayesian methods	
Week 6	**Unit – XI** Estimation of parameters in one-parameter Bayesian models	
	Unit – XII Hypothesis testing in one-parameter Bayesian models	
Week 7	**Unit – XIII** Inference Based on Two-Parameter Model (Normal): Bayesian inference for normal distribution parameters: mean	
	Unit – XIV Bayesian inference for normal distribution parameters: variance	
Week 8	**Unit – XV** Calculation of posterior distributions	
	Unit – XVI Credible intervals in two-parameter models	
Week 9	**Unit – XVII** Posterior Predictive Distributions: Definition and interpretation of posterior predictive distributions	
	Unit – XVIII Applications of posterior predictive distributions in model checking and validation	
Week 10	**Unit – XIX** Introduction to MCMC Techniques (e.g., Metropolis-Hastings): Overview of Markov Chain Monte Carlo (MCMC) methods for Bayesian inference	
	Unit – XX Introduction to the Metropolis-Hastings algorithm and its implementation	
Week 11	**Unit – XXI** Gibbs Sampling: Understanding Gibbs sampling as a special case of MCMC for multivariate distributions	
	Unit – XXII Applications of Gibbs sampling in Bayesian inference and posterior estimation	

Week 12	**Unit – XXIII** Implementation and Use of MCMC Algorithms: Practical implementation of MCMC algorithms using R, Python, or other programming languages	
	Unit – XXIV Using MCMC for parameter estimation, model fitting, and Bayesian hypothesis testing	
Week 13	**Unit – XXV** Hands-on Practice with MCMC Simulations: Guided exercises and simulations to practice MCMC techniques	
	Unit – XXVI Practice continued	
Week 14	**Unit – XXVII** Hands-on experience with running MCMC algorithms, diagnosing convergence, and analyzing results	
	Unit – XXVIII Practice continued	
Week 15	**Unit – XXIX** Advanced Topics in Bayesian Inference: Exploration of advanced topics in Bayesian inference based on student interest and instructor expertise	
	Unit – XXX Discussion of recent developments and applications in Bayesian statistics	
Week 16	**Unit – XXXI** Review and Applications: Recap of key concepts and techniques	
	Unit – XXXII Solving practical problems and case studies	

Textbooks and Reading Material

Textbook:

1. Gelman, A., Carlin, J. B., Stern, H. S., Dunson, D. B., Vehtari, A., & Rubin, D. B. (2013). *Bayesian Data Analysis* (3rd ed.). Chapman and Hall/CRC.
2. McElreath, R. (2015). Statistical Rethinking: A Bayesian Course with Examples in R and Stan. CRC Press.

Suggested Readings:

1. Davidson-Pilon, C. (2015). Bayesian Methods for Hackers: Probabilistic Programming and Bayesian Inference. Addison-Wesley Professional.
2. Martin, O. (2016). Bayesian Analysis with Python. Packt Publishing.
3. Lee, P. M. (2012). Bayesian Statistics: An Introduction. Wiley.

Teaching Learning Strategies

Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

Assignments: Types and Number with Calendar

According to the choice of respective teacher.

Assessment

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2.	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.